



U.S. NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

## 7.3 ENGINEERED SAFETY FEATURES SYSTEMS

### REVIEW RESPONSIBILITIES

Primary - Instrumentation and Control Systems Branch (ICSB)

Secondary - None

### I. AREAS OF REVIEW

This SRP section describes the review for the portion of the protection system used to initiate the operation of the engineered safety features (ESF) systems and essential auxiliary supporting (EAS) systems. This portion of the protection system is called the engineered safety features actuation system (ESFAS). The ESFAS includes both automatic and manual initiation of these systems. This SRP section also includes the review of control systems which regulates the operation of ESF systems following their initiation by the protection system. The ESF control systems include both the automatic and manual features which control the operation of ESF systems.

The review of instrumentation and control systems for EAS systems is included in the SRP sections which address these systems. SRP Section 7.5 includes the information systems important to safety that provide information which is used to indicate the need for manual initiation and for the manual control of ESF systems.

The functional performance requirements of ESF and EAS systems are reviewed by other branches in accordance with the SRP sections which address these systems. The accident analysis described in Chapter 15 of the SAR establishes the bases for monitored variables and the values of monitored variables including associated time delays used to initiate protective system actions. The review verifies that the functional performance requirements of the ESFAS satisfy the design bases for the protection system actions consistent with the accident analysis described in Chapter 15.

The objectives of the review are to confirm that the ESFAS satisfies the requirements of the acceptance criteria and guidelines applicable to the protection system and will perform its safety function during all plant conditions for

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### USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

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which they are required. The review confirms that the control systems for ESF systems satisfies the requirements of the acceptance criteria and guidelines applicable to ESF systems, including their performance requirements.

The review performed for a construction permit application may be based on preliminary designs and the depth of information need only be sufficient to provide reasonable assurance that the final design will conform to the design bases and applicable criteria with an adequate margin for safety. The review performed for an operating license (OL) application is based upon detailed design information that confirms that the final design conforms to the design bases and applicable criteria. The depth of the review for an OL application should be sufficient to conclude that the requirements of the Commission regulations have been satisfied. The depth of the review for the balance of the criteria applicable to the protection system should be sufficient to conclude that the systems conform with the guidelines to the extent required to support the findings of conformance to the regulations.

The review of the information presented and referenced in Section 7.3 of an SAR is directed to the engineered safety features actuation system (ESFAS) and the control systems which are used to regulate the operation of the ESF systems following their initiation by the ESFAS, i.e., the instrumentation and controls used to initiate and control the operation of the engineered safety features.

Typical ESF systems are:

- Containment and Reactor Vessel Isolation Systems
- Emergency Core Cooling Systems (ECCS)
- Containment Heat Removal and Depressurization Systems
- Pressurized Water Reactor (PWR) Auxiliary Feedwater Systems
- Boiling Water Reactor (BWR) Standby Gas Treatment Systems
- Containment Air Purification and Cleanup Systems
- Containment Combustible Gas Control Systems

Typical EAS systems are:

- Electric Power Systems
- Diesel Generator Fuel Storage and Transfer Systems
- Instrument Air Systems
- Heating, Ventilating, and Air Conditioning (HVAC) Systems for ESF Areas
- Essential Service Water and Component Cooling Water Systems

The scope of the ICSB review of Section 7.3 of an SAR includes:

1. The descriptive information, including functional control diagrams (CP), piping and instrument diagrams, and schematic diagrams (OL) pertaining to the ESFAS. The ESFAS includes all electric and electromechanical equipment involved in detecting a plant condition requiring operation of an ESF or EAS system and in initiating the operation of the ESF or EAS system.

2. The descriptive information pertaining to the instrumentation and control systems for the control of ESF systems that are essential to the operation of the ESF systems.
3. The acceptance criteria, guidelines, and design bases used for the design of the ESFAS and the ESF control systems (CP).
4. The applicant's analysis of the conformance to the acceptance criteria, guidelines, and design bases for the ESFAS and for the ESF control systems (OL).

In addition, the ICSB will coordinate with branches that interface with the overall review of ESF systems for the following aspects of ESFAS:

- (1) The adequacy of the monitored variables, i.e., the suitability of parameters, such as pressure, for initiating operation of a given ESF or EAS system.
- (2) The acceptability of the proposed trip setpoints, time delays, accuracy requirements, and actuated equipment response consistent with the safety analysis included in Chapter 15 of the SAR.

The coordinated reviews include the following:

The Power Systems Branch (PSB) evaluates the adequacy of physical separation criteria for cabling and electrical power equipment and determines that control and motive power supplied to redundant systems is from appropriate redundant sources and the adequacy of the instrumentation and controls associated with the proper functioning of the onsite and offsite power systems as part of its primary review responsibility for SRP Sections 8.2, 8.3.1, and 8.3.2.

The Auxiliary Systems Branch (ASB) evaluates the adequacy of the EAS systems to assure that the instrumentation and control aspects of the EAS systems satisfy the acceptance criteria applicable to these systems as part of its primary review responsibility for SRP Chapter 9 and 10. This review confirms that the design of the EAS systems is compatible with the single failure requirements of ESF systems to perform their required safety functions and that the EAS systems that are essential to ESF systems operation will adequately maintain the required environmental conditions in the areas where equipment is located.

The Reactor Systems Branch (RSB) evaluates the adequacy of protective functions consistent with the accident analysis and the operating requirements of the ESF systems as part of its primary review responsibility for ESF Systems in SRP Chapters 5, 6 and 15 of the SAR.

The Equipment Qualifications Branch (EQB) reviews the seismic and environmental qualification of instrumentation and electrical systems as part of its primary review responsibility for SRP Sections 3.10 and 3.11. This includes the design criteria and testing methods and procedures instrumentation and electrical equipment.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the corresponding sections of the SRP.

## 11. ACCEPTANCE CRITERIA

Acceptance criteria and guidelines applicable to the ESFAS and ESF control systems are identified in SRP Section 7.1. The review of Section 7.1 of the SAR confirms that the appropriate acceptance criteria and guidelines have been identified as applicable for these systems. The review of the ESFAS and ESF control systems in this section of the SAR confirms that these systems conform to the requirements of the acceptance criteria and guidelines. The branch technical positions are used when a particular design problem and an acceptable solution have been identified.

Acceptance criteria for the review of ESFAS and ESF control systems are:

1. General Design Criterion 2, "Design Basis for Protection Against Natural Phenomena."
2. General Design Criterion 4, "Environmental and Missile Design Basis."

The following acceptance criteria are applicable to the review of the ESFAS:

1. 10 CFR Part 50, §50.55a(h), "Protection Systems": IEEE Std 279, "Criteria for Protection Systems for Nuclear Power Generating Stations."
2. General Design Criterion 20, "Protection System Function."
3. General Design Criterion 21, "Protection System Reliability and Testability."
4. General Design Criterion 22, "Protection System Independence."
5. General Design Criterion 23, "Protection System Failure Modes."
6. General Design Criterion 24, "Separation of Protection and Control Systems."

In addition, the ESF control systems are reviewed for conformance to the following acceptance criteria\*, applicable to ESF systems with regards to conformance to the single failure criterion on a system basis, and to operability from onsite and offsite electrical power:

1. General Design Criterion 34, "Residual Heat Removal."
2. General Design Criterion 35, "Emergency Core Cooling."
3. General Design Criterion 38, "Containment Heat Removal."
4. General Design Criterion 41, "Containment Atmosphere Cleanup."

Regulatory Guides, Branch Technical Positions, and industry standards that provide information, recommendations and guidance, and in general describe a basis acceptable to the staff that may be used to implement the requirements

\*For ESFAS these requirements are included in the General Design Criteria which specifically address protection systems.

of the Commission regulations identified above are given in SRP Section 7.1, Table 7-1 (Ref. 1) and Appendix 7-A (Ref. 2). In addition, Task Action Plan items are also implemented to meet these regulations as identified in SRP Section 7.1, Table 7-2 (Ref. 3).

### **III. REVIEW PROCEDURES**

This subsection describes the general procedures to be followed in reviewing the ESFAS and ESF control systems. The bases for the evaluation of conformance to the requirements of the acceptance criteria and guidelines may be based upon referenced approved designs. The category or referenced approved designs include topical reports, standard design approvals, and designs of systems which have been reviewed and approved by the staff. If any aspect of a design is not identical to that which is referenced, an evaluation must be made to address the adequacy of the differences and the conclusions included in the safety evaluation report.

Background information of interest in the review of the ESFAS and ESF control systems is found in a number of SAR sections. A list of these is given below for reference purposes. Most of these reference sections also provide background information for other SRP sections in Chapter 7.

- Chapter 1:       for familiarization with the general operation of the plant, both safety and nonsafety aspects.
- Chapter 3:       for a general understanding of the principal architectural and engineering designs of those structures, components, equipment, and systems important to safety.
- Section 3.1:     for exceptions to criteria applicable to the ESFAS and ESF control systems, and for structures suitable for housing this equipment.
- Sections 3.10   for an understanding of the qualification program for  
and 3.11       ESFAS and ESF control system components.
- Chapters 4      for an understanding of the reactor and the reactor coolant  
and 5           system and its interconnections with the ESF systems.
- Chapter 6:       for the design bases, design features, and functional performance requirements of the ESF systems.
- Chapter 8:       for an understanding of the electrical power systems.
- Chapter 9:       for the design bases, design features, and functional performance requirements of essential auxiliary supporting systems.
- Chapter 15:      for the courses of accidents for which the ESF system provides protective functions, the effects of failures of the protective functions, and the assumptions and initial conditions that form the bases of the accident analyses.
- Chapter 16:      for the proposed limiting conditions for operation for the ESF systems and the ESFAS.

Reference to the above sections of the SAR is made to gain an understanding of the purpose of the ESF systems and an understanding of how the ESF systems and the ESFAS are designed and how they are to function.

The General Design Criteria (GDC) include requirements for the ESFAS and the ESF control systems. Review guidance for conformance to the GDC are provided in Appendix A of SRP Section 7.1 (Ref. 4). The review guidance includes references to the guidelines in regulatory guides and industry codes and standards where applicable. An audit review of the ESFAS and ESF control systems should be made to confirm that the systems conform to the guidelines to support the conclusions of conformance to the regulations.

The review is to evaluate the protection system design against the requirements of IEEE Std 279. This procedure is detailed in Appendix B to SRP Section 7.1 (Ref. 5). The procedures in Appendix B address only those design requirements that are specific in nature. For example paragraph 4.9 of IEEE Std 279 requires that the design include means for checking the availability of each system input sensor during operation. Appendix B outlines a straightforward procedure that can be used to determine whether or not this requirement is met.

Appendix B discusses the requirements of IEEE Std 279 and how they are used in the review of the protection system. Although the primary emphasis is on the equipment comprising the protection system, the reviewer should consider the protective functions on a systems level. It is necessary that the ESFAS design be compatible with the ESF systems and EAS systems and that the ESFAS design and the accident analysis are compatible. It is not sufficient to judge the adequacy of the ESFAS only on the basis of the design meeting the specific requirements of IEEE Std 279. It is also necessary to judge the functional relationship between the ESFAS and the ESF systems themselves.

An important part of the review is the engineering drawing review at the OL stage. The drawing review should confirm that the design and layout meet the applicable criteria listed under subsection II.

A site visit should be performed before the evaluation findings are written for an OL. The site visit should include an audit verification that the design and layout criteria reviewed during the drawing review are implemented. An outline of topics for a site visit is provided in SRP Appendix 7-B (Ref. 6).

In certain instances, it will be the reviewer's judgment that for a specific case under review, emphasis should be placed on specific aspects of the design, while other aspects of the design need not receive the same emphasis and indepth review. Typical reasons for such a nonuniform placement of emphasis are the introduction of new design features or the utilization in the design of design features previously reviewed and found acceptable. However, in all cases, the review must be sufficient to conclude conformance to the acceptance criteria, i.e., the requirements of the Commission's regulations.

#### IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that his review supports conclusions of the following type, to be included in the staff's safety evaluation report:

The review of the instrumentation and control aspects of the engineered safety feature (ESF) systems included the engineered safety features actuation systems (ESFAS) and the ESF control systems. The ESFAS detects a plant condition requiring the operation of an ESF system and/or essential auxiliary supporting (EAS) system and initiates operation of these systems. The ESF control systems regulates the operation of the ESF systems following automatic initiation by the protection system or manual initiation by the plant operator.

The staff concludes that the ESFAS and the ESF control systems are acceptable and meet the relevant requirements of General Design Criteria 2, 4, 20 thru 24, 34, 35, 38, and 41 and 10 CFR Part 50, §50.55a(h). This conclusion is based on the following:

We have conducted an audit review of these systems for conformance to guidelines of the regulatory guides and industry codes and standards applicable to these systems. In Section 7.1 of this SER we concluded that the applicant had adequately identified the guidelines applicable to these systems. Based upon our audit review of the system design for conformance to the guidelines, we find that there is reasonable assurance that systems conform fully to the guidelines applicable to these systems.

Our review has included the identification of those systems and components for the ESFAS and ESF control systems which are designed to survive the effects of earthquakes, other natural phenomena, abnormal environments, and missiles. Based upon our review, we conclude that the applicant has identified those systems and components consistent with the design bases for those systems. Section 3.10 and 3.11 of this SER address the qualification programs to demonstrate the capability of these systems and components to survive these events. Therefore, we find that the identification of these systems and components satisfies this aspect of GDC 2 and GDC 4.

Based on our review we conclude that the ESFAS conforms to the design bases requirements of IEEE Std 279 and that the system includes the provision to sense accident conditions and anticipated operational occurrences to initiate the operation of ESF and EAS systems consistent with the accident analysis presented in Chapter 15 of the SAR. Therefore, we find that the ESFAS satisfies the requirements of GDC 20.

The ESFAS conforms to the guidelines for periodic testing in Regulatory Guide (R.G.) 1.22 and IEEE Std 338 as supplemented by R.G. 1.118. The bypassed and inoperable status indication conforms to the guidelines of R.G. 1.47. The ESFAS conforms to the guidelines on the application of the single failure criterion in IEEE Std 379 as supplemented by R.G. 1.53. Based on our review, we conclude that the ESFAS meets the criteria of IEEE Std 279 with regards to the system reliability and testability. Therefore, we find that the ESFAS satisfies the requirement of GDC 21.

The ESFAS conforms to the guidelines in IEEE Std 384 as supplemented by R.G. 1.75 for the protection system independence. Based on our review, we conclude that the ESFAS satisfies the requirement of IEEE Std 279 with regards to the systems independence. Therefore, we find that the ESFAS satisfies the requirement of GDC 22.

Based on our review of the analysis for the ESFAS, we conclude that the system is designed with due consideration of safe failure modes if conditions such as disconnection of the system, loss of energy, or postulated adverse environment are experienced. Therefore, we find that the ESFAS satisfies the requirements of GDC 23.

Based on our review of the interfaces between the ESFAS and plant operating control systems, we conclude that the system satisfies the requirements of IEEE Std 279 with regards to control and protection system interactions.

-OR-

The ESFAS is completely independent of any plant operating control system or channel.

-AND-

Therefore, we find that the ESFAS satisfies the requirement of GDC 24.

Our conclusions noted above are based upon the requirements of IEEE Std 279 with respect to the design of the ESFAS. Therefore, we find that the ESFAS satisfies the requirement of 10 CFR Part 50, §50.55a(h) with regards to IEEE Std 279.

Our review of the ESF control systems included conformance to the requirements for testability, operability with onsite and offsite electrical power, and single failures consistent with the General Design Criteria applicable to these ESF systems. We conclude that the ESF control systems are testable and are operable on either onsite or offsite power (assuming only one source is available) and that the controls associated with redundant ESF systems are independent and satisfy the single failure criterion and therefore meet the relevant requirements of GDCs 34, 35, 38, and 41.

The applicant has also incorporated into system design the recommendation of Task Action Plan item [identify item number and how implemented] which we have reviewed and found acceptable.

Our review of the ESFAS and ESF control systems has examined the dependence of these systems on the availability of essential auxiliary supporting (EAS) systems. Based on our review and coordination with those having primary review responsibility of the EAS systems, we conclude that the design of the ESFAS and ESF control systems are compatible with the functional performance requirements of EAS systems. Therefore, we find the interfaces between the design of ESFAS and ESF control systems and the design of EAS systems to be acceptable.

The conclusions noted above for the ESFAS and ESF control systems are applicable to all portions of the systems except for the following for which acceptance is based upon prior Commission review and approval as noted.

[List applicable system or topics and identify references]



## **V. IMPLEMENTATION**

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREGs.

## **VI. REFERENCES**

1. Standard Review Plan Section 7.1, Table 7-1, "Acceptance Criteria and Guidelines for Instrumentation and Control Systems Important to Safety."
2. Standard Review Plan Appendix 7-A, "Branch Technical Positions (ICSB)."
3. Standard Review Plan Section 7.1, Table 7-2, "TMI Action Plan Requirements for Instrumentation and Control Systems Important to Safety."
4. Standard Review Plan Section 7.1, Appendix A, "Acceptance Criteria and Guidelines for Instrumentation and Control Systems Important to Safety."
5. Standard Review Plan Section 7.1, Appendix B, "Guidelines for Evaluation of Conformance to IEEE Std 279."
6. Standard Review Plan Appendix 7-B, "General Agenda, Station Site Visits."

APPENDIX A

STANDARD REVIEW PLAN SECTION 7.3

USE OF IEEE Std 279 IN THE REVIEW OF THE ESFAS AND  
INSTRUMENTATION AND CONTROLS OF ESSENTIAL AUXILIARY SUPPORTING SYSTEMS

(Appendix A to SRP Section 7.3 has been superseded by Appendix B to SRP  
Section 7.1)